Part II

Transportation and the Environment

CHAPTER SIX

ENVIRONMENTAL IMPACTS OF TRANSPORTATION

SINCE THE APPLICATION OF STEAM POWER TO SHIPS AND LOCOMOTIVES IN THE EARLY 19TH CENTURY, MOTORIZED TRANSPORT HAS HAD AN INFLUENCE ON NEARLY EVERY ASPECT OF SOCIETY, FROM THE ORGANIZATION OF ECONOMIC ACTIVITIES, TO THE GEOGRAPHY OF CITIES, TO THE PATTERNS OF SOCIAL LIFE. ITS IMPORTANCE CAN BE GAUGED BY THE FACT THAT, AS NOTED IN CHAPTER 2, TRANSPORTAtion accounts for about one-ninth of the U.S. economy measured in terms of gross domestic product (GDP). Although transportation is vital to the U.S. economy and an indispensable part of contemporary society, it also generates undesirable byproducts that adversely affect environmental quality and human health. Emissions from transportation vehicles and the production and handling of fuels are two of the leading causes of air quality problems. Carbon dioxide (CO_2) emissions from transportation-related combustion of fossil fuels are increasing the concentration of greenhouse gases, which threatens to alter the earth's climate. Motor vehicles and airplanes are major sources of undesirable noise in metropolitan areas. Discarded motor vehicles are a significant source of solid waste. Crude oil and gasoline leaks and spills pollute water and groundwater resources Moreover, transportation infrastructure not only directly uses land, thereby impacting habitats for flora and fauna, but also

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supports the transformation of rural land to urban uses, often in the form of urban sprawl.[1]

Most facets of transportation-related environmental impacts—from air pollution to noise pollution to oil spills—have been addressed by some type of policy action. Major public policy responses to transportation-related environmental problems originated in several laws enacted in the late 1960s and early 1970s. Many of the policies implementing these laws have been regulatory: standards specifying allowable rates of pollution or rules encouraging or requiring the use of less polluting technologies. Over the years these laws have been revised and generally strengthened as transportation activities have grown and regulations have been reevaluated (see box 6-1 for a list of transportation-related environmental laws).

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[1] In addition to the direct impacts of transportation, "upstream" activities necessary for transportation to take place—including oil field exploration and development, petroleum refining and storage, and vehicle manufacturing—can have significant environmental impacts as well.

Box 6-1: Selected Federal Laws Addressing the Environmental Impacts of Transportation

Broadly Applicable Laws

- Urban Mass Transportation Act of 1964
- National Historic Preservation Act of 1966
- Department of Transportation Act of 1966 (section 4(f), Preservation of Parklands)
- National Environmental Policy Act of 1969
- Airport and Airway Development Act of 1970
- Federal Aid to Highways Act (various years)
- Intermodal Surface Transportation Efficiency Act of 1991

Air Quality

- Clean Air Act (major amendments in 1965, 1970, 1977, and 1990)
- Energy Policy Act of 1992

Noise Pollution

- Housing and Urban Development Act of 1965
- Noise Control Act of 1972
- Airport Noise and Capacity Act of 1990
- Control and Abatement of Aircraft Noise and Sonic Boom Act of 1968

Water Quality (including oil spills)

- Clean Water Act (major amendments in 1972, 1977, and 1987)
- Safe Drinking Water Act
- Oil Pollution Act (1990)

Protection of Environmentally Sensitive Areas, Rare Species, and Wildlife

- Fish and Wildlife Coordination Act of 1958
- The Wild and Scenic Rivers Act of 1968
- The Endangered Species Act of 1973

Marine and Coastal Areas Protection

- Ocean Dumping Act and Amendments (1972, 1982, and 1992, among others)
- Coastal Zone Management Act of 1972
- The Coastal Wetlands Planning, Protection, and Restoration Act (1990)
- The Nonindigenous Aquatic Species Nuisance Species Prevention and Control Act (1990)
- Shore Protection Act of 1988

Transportation of Materials, including Solid and Hazardous Waste

- Resource Conservation and Recovery Act of 1976
- Superfund Amendments and Reauthorization Act of 1986
- Used Oil Recycling Act of 1980
- Hazardous Materials Transportation Act, as amended
- Sanitary Food Transportation Act of 1990

cases the results have fallen short of expectations. Measuring success can be complex; the same body of data can give rise to quite different interpretations of environmental progress, depending on the time period and the environmental indicators selected for examination. In the case of air pollution, for example, the data show that, compared with the 1970s, emissions per vehicle-mile are significantly lower for all regulated pollutants and total transportation emissions are down. These reductions, together with other sectors' successes, have produced measurable improvements in metropolitan air quality. Still, many metropolitan areas fall short of national air quality standards, and emissions of some pollutants have increased recently, leading to concern about whether the clear progress made in the 1980s will continue.

The lack of clear solutions to environmental problems has led some to propose a new goal for transportation: *sustainability*. The World Commission on Environment and Development has defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Whether a practical, operational definition of sustainability can be developed to form the basis of transport-related environmental policy remains to be seen. The intent, however, is to protect the environment and assure adequate resources for society for the indefinite future. The goal of sustainability has encouraged the international community to debate new environmental strategies, including those that seek to enlist market forces in the effort to address environmental quality.

This chapter provides a brief overview of transportation-related environmental impacts. It also discusses a key concept of environmental economics, externalities, which is necessary to understand both existing and potential policy approaches. Finally, this chapter presents a description of data needed to monitor the environmental impacts of transportation, particularly in relation to federal legislation and regulations affecting the transportation sector.

Transportation-Related Environmental Impacts

► Air Pollution

Air pollution is the most studied environmental impact of transportation. Burning of fossil fuels in internal combustion engines produces a variety of pollutants, including carbon monoxide (CO), volatile organic compounds (VOCs), and particulates. In addition, internal combustion engines oxidize nitrogen, the principal constituent of air, thereby producing various oxides of nitrogen. During transportation, storage, and refueling, liquid fuels evaporate, further adding to the amount of hydrocarbon emissions. Impurities and additives in fuel result in additional particulate and gaseous pollution.

Carbon monoxide is readily absorbed into the bloodstream where it can reduce oxygen delivery to organs and tissues. Exposure to high levels decreases visual perception, work capacity, manual dexterity, learning ability, and performance of complex tasks. VOCs and nitrogen oxides (NO_x) are the principal precursors to the formation of ozone. Ozone is the major constituent of smog. It is formed in the lower atmosphere by a photochemical reaction promoted by heat and sunlight. Ozone in the lower troposphere contributes to respiratory diseases and reduced lung function. It also causes foliar damage in crops and trees, leading to annual crop losses of several billion dollars in the United States alone. (USEPA 1994)

Particulate matter also contributes to smog. It consists of dust, dirt, soot, smoke, and liquid droplets released directly into the air by sources such as factories, powerplants, fires, and automobiles. Particulate matter also causes damage to materials and soil and is a major cause of visibility impairment in many parts of the United States. Particulate matter that is smaller than 10 microns (PM-10) is more likely to be responsible for adverse health effects. The major effects of these particulates include aggravation of existing respiratory and cardiovascular disease, alterations in the body's defense systems against foreign materials, damage to lung tissue, and in some cases, carcinogenesis. As with most air pollutants, those most susceptible to adverse effects include individuals with chronic obstructive pulmonary or cardiovascular disease, influenza, and asthma, and the elderly and children.

In the United States, lead additives in fuel have been eliminated with the conversion to unleaded gasoline. As a result, airborne lead from the combustion of fuel—once the primary source of airborne lead particles—is no longer significant. Leaded gasoline is, however, still widely used in many developing countries and has yet to be fully phased out in some developed countries. Exposure to excessive amounts of lead can harm both adults and children by causing damage to the nervous system, gastrointestinal tract, and blood-forming tissues.

Some other transportation-related toxic air pollutants include benzene, polynuclear aromatic hydrocarbons, formaldehyde, toluene, ammonia, cyanide, hydrogen sulfide, ethylene, and dioxin. These emissions can cause varying degrees of health problems.

In addition to local and regional environmental impacts, transportation emissions contribute to international environmental problems. These include acid rain, global warming, and stratospheric ozone depletion. Oxides of nitrogen and sulfur contribute to acid rain, which can damage forests and vegetation and adversely affect aquatic species.

When burned, hydrocarbon fuels produce CO_2 and water vapor. Both are greenhouse gases, but only CO_2 accumulates in the upper atmosphere in a way that can affect global climate. Greenhouse gases also naturally occur in the earth's atmosphere and are essential for the continuation of life. They are transparent to short-wave radiation from the sun but absorb and trap long-wave radiation within the atmosphere, which can raise the average global temperature. Scientists have established that the amount of heat trapped is affected by greenhouse gas concentrations, but are uncertain about the exact degree to which these gases will affect global temperatures and precisely what regional climatic changes will occur. Even a slight increase in the global mean temperature would alter natural and agricultural ecosystems by changing the distribution of climatic resources (e.g., patterns of rainfall). In addition, global warming could cause melting of polar ice caps, thereby increasing the sea level and leading to coastal flooding.

Another global environmental problem, stratospheric ozone depletion, is influenced by transportation, primarily because of past use of chlorofluorocarbons (CFCs) in automotive air conditioners. Ozone molecules in the stratosphere act as a protective shield for life on earth by absorbing ultraviolet radiation, a known cause of skin cancer. CFCs destroy ozone molecules, increasing the risk of such impacts. Now subject to an international agreement, CFCs are being phased out and replaced with less damaging compounds.

► Noise

People living near airports, major highways, railroad tracks, and other transportation facilities may be exposed to much noise. The impact of noise depends on the frequency, pitch, loudness, and duration of the sound. Transportation noise can be of a short duration, for example backfires, but is usually persistent. Prolonged exposure to noise can have a range of health effects, contributing to anxiety, depression, and insomnia. For most people, transportation noise does not pose a threat of permanent hearing damage.

Water Pollution

The major source of water contamination from the transportation sector comes from oil and fuel leaks and spills from a variety of sources, including tankers, motor vehicles, and above- and below-ground fuel storage tanks. Oil spills from tankers can have major impacts on nearby ecosystems, aquatic species, wildlife, and birds, but the extent and severity of environmental contamination vary greatly with the location and size of the spill. Even a small amount of petroleum in the groundwater system can contaminate large quantities of water.

Runoff from roads, infrastructure construction, and the deterioration of discarded vehicles also have an impact on surface and groundwater quality. The amount and magnitude of highway runoff depend on traffic characteristics, maintenance activities, and climatic conditions, as well as the location of the road itself. (USDOT FHWA 1987) For example, runoff from roads and parking lots has a higher than normal concentration of toxic metals, suspended solids, and hydrocarbons, which alter the composition of surface and groundwater. (Hahn and Pfeifer 1994) In northern regions, the application of road salts in winter is another concern. Increased sodium levels in water and surrounding soils can damage vegetation.

Moreover, transportation infrastructure may cause changes in the local water table and drainage patterns by increasing the share of rainwater that becomes runoff. This, in turn, affects the soil moisture content of the area, which, in turn, may alter vegetation and wildlife. Although these effects may be localized, transportation-related construction activities are so extensive that they cannot be ignored.

Solid Waste

Solid waste generated from the disposal of obsolete vehicles, paving and other materials, and construction adds to landfills, contributes to air pollutant emissions if incinerated, and contaminates water systems. Although about 75 percent of the weight of an average car is recycled (Holt 1993), about 3.5 million tons from scrapped cars wound up in landfills in 1994. Old tires, lead and acid in batteries, and pavement add to the waste stream from the transport sector. Despite recycling successes, the improper disposal of materials and the inability to recycle all solid waste remains a serious problem. In recent years, advances in lighter weight plastics, ceramics, and composite materials have shifted the composition of motor vehicles to a higher nonferrous content. These advanced materials increase fuel economy by reducing vehicle weight, but also complicate recycling.

Although more than 80 percent of asphalt is reclaimed and used in highways and other transportation applications, it is still a significant source of solid waste. Reclaimed concrete is used less frequently.

Land Use and Habitat

Transportation also has a direct effect on the environment through changes in land use and habitat. In the United States, paved and unpaved public roads occupy 25,000 square miles of land, an area equal to the size of West Virginia. If off-street parking, garages, carports, and driveways are included, the land area increases to 29,000 square miles. (Delucchi 1995) (Because the U.S. transportation system is highly developed, relatively little additional land is converted to new transportation uses each year.) Transportation infrastructure causes modification of vegetation, changes in drainage patterns, the creation of microclimates, and changes in habitat. Indeed, highways, runways, railroad tracks, and some other transportation infrastructure often fragment animal habitats by creating barriers between previously joined areas. The degree to which habitats are affected depends partly on traffic density. Furthermore, slight changes in moisture content of an area can cause the migration or disappearance of some species from that area. Other species that are dependent on or interact with these species may also be affected. In some cases, wetlands are destroyed by development linked to urban sources, including transportation.

Indirectly, transportation also contributes to much more extensive land-use changes. The availability of inexpensive and efficient transportation promotes the conversion of rural land into low-density urban use, often termed urban sprawl. Many people prefer lower population densities and larger home lots even at the price of driving longer distances to work and shop. This preference increases the amount of developed land, contributing to habitat alteration. Moreover, the increase in travel often translates into greater production of residuals. How to balance the benefits of inexpensive, efficient mobility and low-density residential living with its related environmental costs presents a major challenge.

Environmental Damage: The Concept of Externalities

Markets have difficulty assigning monetary values to environmental damage produced by the byproducts of transportation. These costs are external to the price of a good or service and thus are referred to as negative externalities. External benefits also can be attributed to transportation. Appendix B discusses both external costs and benefits in detail.

Although a precise and comprehensive definition of a negative externality does not exist, it can be thought of as a cost (such as damage from air pollution) imposed on society by an activity (such as motor vehicle use), which does not affect the price of a good or service. To the extent that travelers and shippers do not pay for these consequences, they have little economic incentive to consider them in their decisionmaking. In theory, if these external costs were routinely and predictably added to the price of transportation, the market itself would promote more "efficient" production and consumption decisions. In that event, a transportation option that entails relatively little environmental damage could be offered at a lower price than other options that entail more environmental damage. But, ordinarily, this will not happen unless some mechanism exists to force consideration of external costs.

The environmental costs to society of transportation are not trivial but cannot be quantified precisely. Some forms of environmental damage—effects on scenic resources, for instance—are very hard to express in economic terms. National estimates of external costs of transportation-related air pollution range from 0.03 to 1.05 percent of GDP. For Organization for Economic Cooperation and Development (OECD) countries, the costs are estimated at 0.4 percent of GDP, or 0.1 to 0.3 cents per kilometer (the OECD estimate includes pollution from all motor vehicles). (Quinet 1989; Sperling and Shakeeh 1995, 112) At the present time, estimates of external costs of greenhouse emissions are not reliable.

The inability of markets to price these environmental effects in the cost of transportation has been a rationale for government intervention through environmental policies and standards. Federal emissions standards for newly manufactured highway vehicles, initially imposed in the late 1960s and early 1970s, are examples. In response, vehicle manufacturers designed new vehicles that pollute less than their predecessors. In addition, alternative fuels and alternate fuel vehicles significantly lower the per-vehicle-mile rate of emissions. Battery-powered electric vehicles produce no exhaust emissions directly but do so indirectly, from the powerplants that provide the electricity needed to charge their batteries.

Figures 6-1a–d illustrate the impact on air pollution externalities and vehicle-miles traveled under four different market situations. Figure 6-1a represents the market situation when the environment is not a factor. The market supply curve (S) represents the cost of an additional mile of travel at each level of travel, and the market demand curve (D) shows the marginal benefit of an additional mile. The market demand curve slopes downward, indicating that the first few miles traveled are extremely valuable in comparison to the last few. Conversely, the supply or marginal cost curve slopes upward, reflecting the fact that resources must be reallocated from other areas of the economy in order to produce additional transportation. With each additional unit of transportation output, opportunity costs increase as fewer other valued goods can be produced. At the point where the two curves meet, private cost equals private benefit. The intersection of the supply and demand curves occurs at price P1 and quantity Q1.

Markets will only produce maximum societal benefits when private costs and benefits are equal to social costs and benefits. For this to occur, transportation-related pollution costs must be added to the private costs, as illustrated in figure 6-1b—total social cost (S′) of transportation activities is equal to the sum of the private costs plus environmental damage costs.

In theory, when full social costs are considered (e.g., users pay the actual social cost of each mile via some artificial pricing structure), the market system will adjust so that social costs equal social benefits. As shown in figure 6-1c, the higher price of transportation would result in fewer miles traveled, decreasing from quantity Q1 to quantity Q′.

Creating a price structure to reflect full social costs, however, is only one way to deal with external costs. As noted earlier, technology plays an important role in determining the amount of pollution produced by transportation. In particular, pollution control technologies strongly affect the rate of emissions per mile—a key component of total vehicle emissions.

Although highway vehicle travel increased by over 100 percent from 1970 to 1994, several kinds of emissions from highway sources decreased significantly. This trend can be attributed to technological changes required by the previously mentioned federal emissions standards. The effect of reductions on pollution rates is to shift the social cost curve (S″) much closer to the private cost curve (P″), as shown in figure 6-1d. Thus, technology makes it possible to reduce environmental damage and consequently total social cost (P″), with a smaller decrease in the quantity of travel (Q″) than shown in figure 6-1c.

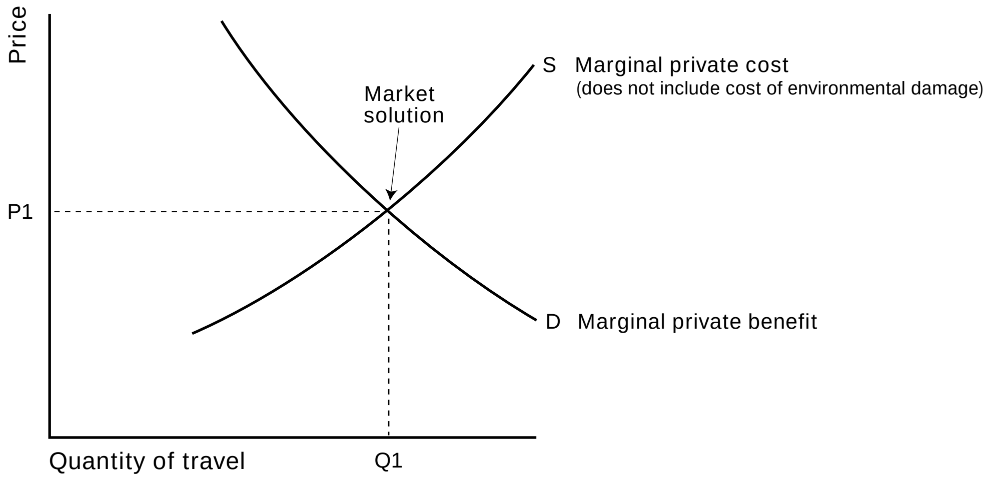
► Internalizing Environmental Effects

Increasingly, U.S. environmental policy entails a mix of market incentives, regulations, and other measures such as information programs. Although all of the measures have the potential to reduce the quantity of residuals produced, thus helping to reduce the cost of environmental damage, each has drawbacks that need to be considered. (US Congress OTA 1995)

Regulatory policies have been the most widely applied approach for addressing environmental problems. Examples include motor vehicle emissions standards, aircraft engine noise standards, and oxygenated fuel requirements.

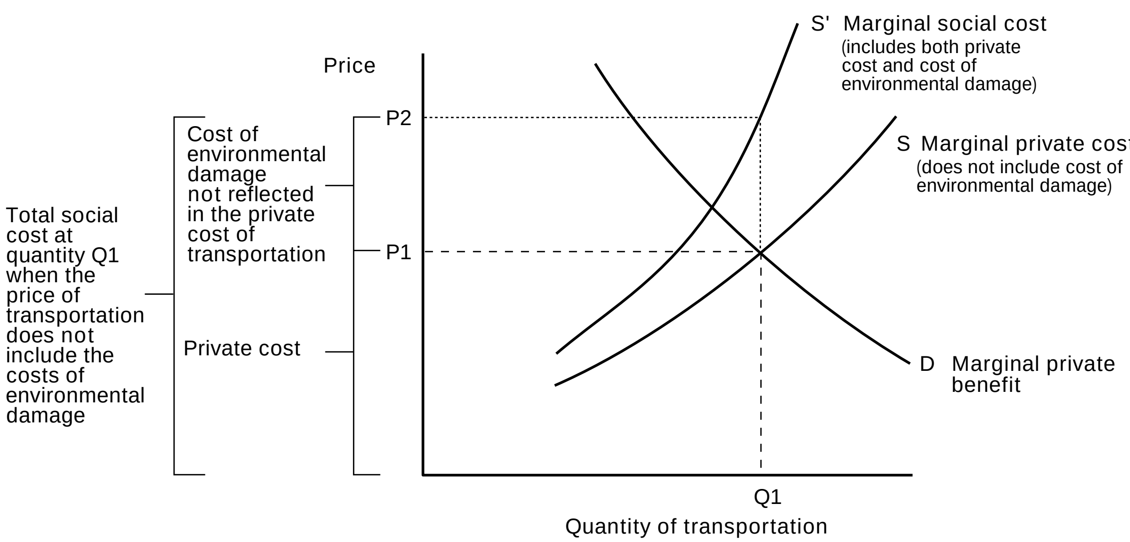
Regulatory measures sometimes lack flexibility, however, and may also be costly to administer and enforce. Automotive emissions standards, for example, apply equal per-mile emissions rates to an entire class of new vehicles (e.g., gasoline passenger cars and diesel light trucks)

Figure 6-1a: Price and Quantity of Transportation When Environmental Costs are not a Factor



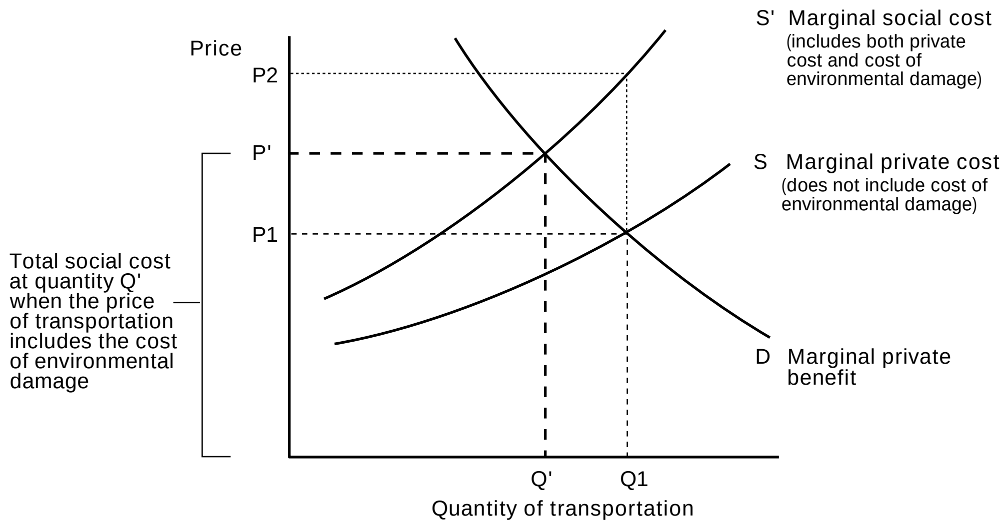
NOTE: Intersection of S and D indicates the market solution at which marginal private cost equals marginal private benefit.

Figure 6-1b: Cost Curve S′ Representing Both Private Cost and Cost of Environmental Damage



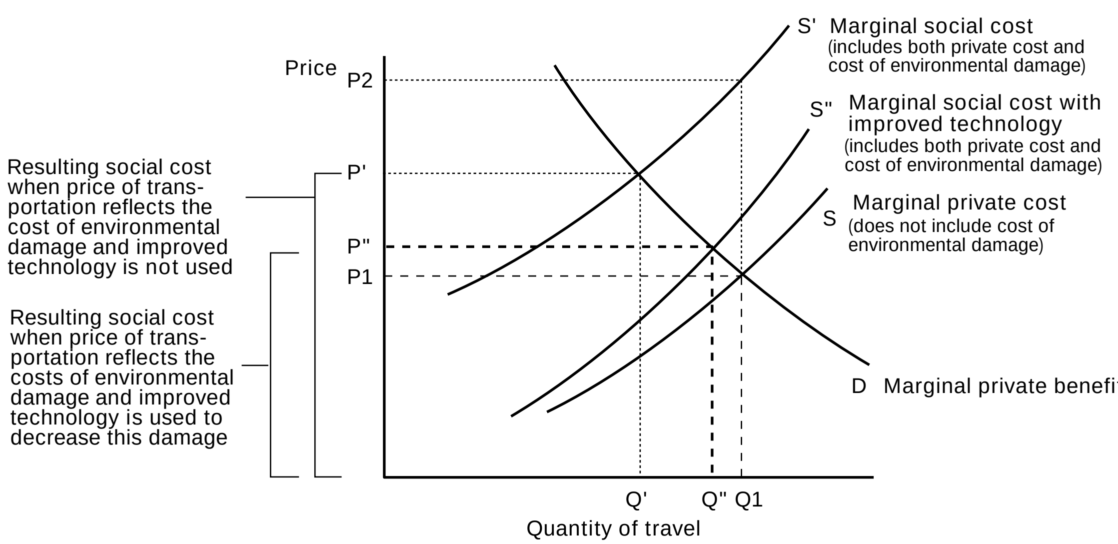
NOTE: The difference between S and S' at quantity Q1 represents the costs of the environmental damage of transportation consumed at quantity Q1.

Figure 6-1c: Market Solution When Costs of Environmental Damage are Internalized



NOTE: The intersection of D and S' is a generalized representation of the price of transporation that would result if all environmental damage costs were internalized so that users actually paid for this damage. Less transportation results from this change in price.

Figure 6-1d: Market Solution When Improved Technology Decreases the Rate of Environmental Damage



NOTE: The intersection of D and S" is a generalized representation of the price and quantity of transportation that might result if technological improvements are used to reduce the rate at which a given amount of travel generates pollution. Transportation's price would be higher and its quantity lower than when the costs of environmental damage are not included in the price of transporation (intersection of D and S). But the social costs associated with a given amount of environmental damage would be lower, and would result in less descrease in travel, than if environmental costs are internalized without the use of improved technology (intersection of D and S').

despite the cost differentials for achieving emissions reduction. In addition, standards apply to emissions measured by fixed procedures under specified laboratory conditions. If real-world conditions are not accurately reflected in the measurement methods, real-world performance is likely to fall short of the regulatory goal. This has become a concern with the federal automotive emissions standards (see chapter 8).

A variety of market-based incentives exist or have been proposed to internalize environmental costs. Some, such as emissions trading or banking, assign property rights to environmental resources. These rights can be bought, sold, traded, or otherwise used by their owner. In theory, emissions trading could help to eliminate exploitation of the environment beyond its efficient use, because the market will account for environmental costs in arriving at the quantity and means of producing transportation services.

In a few cases, assigning property rights for pollution or other residuals already has been used to address environmental externalities in transportation. In the 1970s and 1980s, for example, the Environmental Protection Agency (EPA) authorized credits to refiners for lead removal in gasoline that exceeded a prescribed phase-down schedule. Under this program, credits could be banked or traded with other refiners. EPA estimates that without the program it would have cost refiners an additional $226 million to phase out lead. Fee rebate systems also have been used or proposed to assure proper disposal of batteries, tires, and other solid waste. In addition, a regional clean air incentives market (RECLAIM) was set up in the Los Angeles area in 1994, which includes emissions trading for NO_x and sulfur dioxide. Although primarily oriented toward stationary sources, RECLAIM includes credits for reducing emissions by scrapping old automobiles.

Pollution charges or taxes have also been proposed, and, in some cases, used to address environmental externalities. In theory, a charge or tax equal to the cost of damage would eliminate the difference between societal and private costs.

Devising an optimal tax or charge is often very difficult, however. The tax must be levied directly on the residual's damage in order to elicit the correct responses, including behavior modification and technological innovation. Taxing only vehicle-miles driven is unlikely to produce the desired results, because differences in emissions rates due to differences in technology and driving styles would be unaffected. Moreover, it is difficult to devise a tax that reflects the environmental damage produced by residuals, and not just their quantity. For example, hydrocarbon and nitrogen oxide emissions are more troublesome when weather conditions favor ozone formation (hot, sunny days when the air is stagnant). A fuel tax would differ from the vehicle-miles-traveled tax in that it would also provide an incentive to increase vehicle fuel economy. As discussed above, however, there are conceptual drawbacks to taxes on surrogates.

Many states employ pollution charges or taxes of one sort or another. Their use at the federal level is limited, although there are examples, such as a provision in the 1990 Clean Air Act Amendments that levied a per-pound charge on CFC use, depending on ozone depletion impacts and other pollution charges.

Current Data Needs

Prior to the 1970s, few laws required environmental impact assessments or standards for environmentally safe levels of residuals. Today, more than 20 laws have provisions that address many environmental impacts from transportation. Measures range from broadly applied legislation, such as the National Environmental Policy Act or the Endangered Species Act, to measures that target transportation-related environmental impacts, such as the Clean Air Act and Amendments and the Noise Control Act of 1972 (see table 6-1). To be effective in this complex environment, accurate and comprehensive sources of data and information on the environmental impacts of transportation are needed. Moreover, data need to be understandable and available to the public. To this end some have suggested the development of a series of performance indicators for environmental quality. (President's Council on Sustainable Development 1996)

A good deal of progress in data collection and dissemination has been made over the past 25 years, particularly in the realm of air quality. A nationwide air monitoring system records daily variations in air quality. Moreover, through the Travel Model Improvement Program, the Department of Transportation (DOT), EPA, and the Department of Energy are working to improve travel forecasting procedures in order to respond to environmental and other concerns. (USDOT USEPA USDOE 1996) To advance our understanding of air quality, EPA recently has taken steps to improve its estimation of motor vehicle emissions in real-world conditions.

DOT and EPA are charged with preparing triennial reports on air quality-related transportation programs, called for by Section 108(f)(3) of the Clean Air Act. The studies assess existing state and local programs, including adequacy of funding, and the extent to which DOT air quality-related transportation programs comply with and meet goals of the Clean Air Act. The first report was issued in 1993 (USDOT and USEPA 1993); the second is expected in 1996.

Unfortunately, other aspects of environmental quality are less well documented. Until recently, EPA's inventory of toxic emissions focused on manufacturing, making it of little use for understanding transportation emissions. Data is even scantier, in general, for transportation-related impacts on surface and groundwater resources, animal habitats, and land use. For instance, the nationwide effects of groundwater contaminants from highway runoff—including oil, antifreeze, and salt—are largely unknown. And more needs to be known about the interactions between transportation and land use, particularly in terms of what is dubbed the "costs of sprawl." Impacts of transportation on biodiversity are also poorly understood.

Finally, a weakness of environmental data is that it does not show the real impact of the pollutants produced by transportation. To what extent does transportation pollution damage human health? What are the effects of transportation pollution on crop yields? How and to what extent do transportation activities affect ecosystems? These are difficult questions, but they must be answered in order to assess the actual environmental impact resulting from transportation.

Such an effort will likely be an important part of developing indicators of progress toward sustainability. Proponents of such an approach have proposed goals of sustainability like the conservation of nature, stewardship of natural resources, and health and the environment. One indicator of the conservation of nature might be the amount of wetlands and other habitat loss. Resource stewardship indicators might reflect measures of materials consumption, waste reduction (including recycling), energy efficiency, and renewable resources. Indicators of progress on health and the environment might include estimates of the number of people living with unhealthy air and water.

The environment is only part of the sustainable development equation. The other equally critical component is to encourage development that meets the needs of current and future generations. Hence, some argue that ways need to be found to weigh the unintended consequences of transportation against its benefits. These include not only environmental damage but fatalities and injuries from crashes. For this reason some are now proposing a full-cost accounting in order to measure the full social costs and benefits of transportation (see appendix B). Clearly, this places an even greater emphasis on the ability to collect data on the wide range of transportation impacts. Moreover, full-cost accounting raises difficult issues with regard to costing things such as ecosystem damage, the destruction of species, and people's lives. Yet, such an enterprise, while difficult and expensive, promises to help distribute resources in the most productive and efficient possible way.

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